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## SAFETY GUIDE 9

### SELECTION OF DIESEL GENERATOR SET CAPACITY FOR STANDBY POWER SUPPLIES

#### A. Introduction

General Design Criterion 17 requires that the onsite (standby) power supply for a nuclear power plant be of sufficient capacity and capability to assure that (1) specified acceptable fuel design limits and design conditions of the reactor coolant pressure boundary are not exceeded as a result of anticipated operational occurrences and (2) the core is cooled and containment integrity and other vital functions are maintained in the event of postulated accidents. Diesel generator sets have been widely used as the power source for the standby power supplies. This safety guide describes an acceptable basis for the selection of diesel generator sets of sufficient capacity and margin to implement General Design Criterion 17.

#### B. Discussion

A diesel generator set selected for use as a standby power supply should have the capability to (1) start and accelerate a number of large motor loads in rapid succession, and be able to sustain the loss of any such load, and (2) supply continuously the sum of the loads needed to be powered at any one time. This guide provides an acceptable way of assuring these objectives are met. The considerations involved in the need for the diesel generator to start and achieve rated conditions in a short period of time are evaluated on an individual case basis.

A knowledge of the characteristics of each load is essential in establishing the bases for the selection of a diesel generator set that is able to accelerate large loads in rapid succession. The majority of the emergency loads are large induction motors. This type of motor draws, at full voltage, a starting current five to ten times its rated load current. The sudden,

large increases in current drawn from the diesel generator resulting from the startup of induction motors can result in substantial voltage reductions. The lower voltage could prevent a motor from starting or cause a running motor to coast down. Other loads also might be lost if their contactors drop out. Recovery from the transient caused by starting large motors or from the loss of a large load could cause diesel engine overspeed which, if excessive, might result in a trip of the machine. These same consequences also can result from the cumulative effect of a sequence of more moderate transients if the system is not permitted to recover sufficiently between successive steps in a loading sequence.

Generally it has been industry practice to specify a maximum voltage reduction of 15 percent when starting large motors from large capacity power systems and a 25 to 30 percent voltage reduction when starting these motors from limited capacity power sources such as diesel generator sets. Large induction motors supplied with nominal voltage can achieve rated speed in less than 5 seconds when powered from adequately sized diesel generator sets which are capable of restoring the voltage to 90 percent of nominal in about 1 second.

Protection of the diesel generator set from excessive overspeed, which can result from a loss of load, is afforded by the provision of a diesel generator set trip, usually set at 115 percent of nominal speed.

A problem arises in assessing whether the goal of continuously supplying the sum of the needed loads is achieved with sufficient capacity and margin, because of the various interpretations of load ratings quoted by diesel generator suppliers. The load ratings represent the loads at which the set can operate continuously with a high availability, if various specified mainte-

nance programs are followed. The nominal rating, used as a datum for the overload ratings, has been termed variously the "continuous," "guaranteed," or "long term" rating. The definition used throughout this guide for "continuous rating" is "that load for which the supplier guarantees continuous operation at a high availability (expected to be about 95%) with an annual maintenance interval". The overload ratings are similarly defined except that the specified maintenance intervals are shorter. For example, the following are the load ratings of a typical diesel generator set:

| <i>Ratings</i>     | <i>Maintenance Interval</i> |
|--------------------|-----------------------------|
| Continuous 2500 kW | Annual (8760 hr)            |
| Overload 2850 kW   | 2000 hr                     |
| 2950 kW            | 7 day                       |
| 3050 kW            | 30 min                      |

If the power output is increased into the overload ratings, wearout is accelerated and the maintenance interval needed to assure high reliability is reduced. This discussion assumes that the diesel generator set is utilized solely as a standby power supply and that it does not serve a secondary function such as power generation for peak demand periods of a transmission network. The secondary functions, since they would affect wearout and availability of the diesel generator set, will be evaluated on an individual case basis. If found acceptable, the total amount of operation between maintenance intervals will be limited by the technical specifications. This guide covers diesel generator sets used solely as a standby power supply which is the design most widely adopted.

The tabulation illustrates the sensitivity of the deterioration rate to increases in load above the continuous rating. For example, if the design basis loading were that corresponding to the 2000-hour rating, an error of only 8 percent in estimating the loads could result in operation at the 30-minute rating. Although operation at the 30-minute rating would not be expected to stall the engine, such operation could lead to the danger of early failure.

The uncertainties inherent in estimates of safety loads at the construction permit stage of design are of such magnitude that it is prudent to provide a substantial margin in the selection of the diesel generator set load capability. This margin can be provided by esti-

imating the loads conservatively and by selecting the continuous rating of the diesel generator set so that it exceeds the sum of the loads needed at any one time. A more accurate estimate of safety loads is possible during the operating license stage of review due to the completion of the detailed designs and the availability of preoperational test data. This permits the consideration of a somewhat less conservative approach, such as operation with safety loads within the 2000 hour overload rating of the diesel generator set. A conservative estimate of safety loads based on design or measurements taken during preoperational testing of engineered safety features does not, however, represent with certainty the actual loads experienced under accident conditions. Therefore, an adequate margin is still essential.

### C. Regulatory Position

1. At a time when the characteristics of loads are not accurately known, such as during the construction permit stage of design, each diesel generator set on a standby (onsite) power supply should be selected to have a continuous load rating equal to or greater than the sum of the conservatively estimated loads needed to be powered at any one time. In the absence of fully substantiated performance characteristics for mechanical equipment such as pumps, the electric motor drive ratings should be calculated using conservative estimates of these characteristics. (For example, pump run-out conditions and motor efficiencies of 90% or less.)
2. At the operating license stage of review, the predicted loads should not exceed the smaller of the 2000-hour rating, or 90 percent of the 30-minute rating of the set.
3. During preoperational testing, the predicted loads should be verified by tests.
4. Each diesel generator set should be capable of starting and accelerating to rated speed, in the required sequence, all the needed engineered safety feature and emergency shutdown loads. At no time during the loading sequence should the frequency and voltage de-

crease to less than 95 percent of nominal and 75 percent of nominal, respectively. During recovery from transients caused by step load increases or resulting from the disconnection of the largest single load, the speed of the diesel generator set should not exceed 75 percent of the difference between nominal speed and the overspeed trip set point or 115 percent of nominal, whichever is

lower. Voltage should be restored to within 10 percent of nominal and frequency should be restored to within 2 percent of nominal in less than 40 percent of each load sequence time interval.

5. The suitability of each diesel generator set of the standby power supply should be confirmed by prototype qualification test data and preoperational tests.